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journal or publication title	Tohoku journal of agricultural research
volume	21
number	2
page range	60-72
year	1970-12-19
URL	http://hdl.handle.net/10097/29587

Tohoku Journal of Agricultural Research
Vol. 21 No. 2, June 1970
Printed in Japan

Growth Analysis of six Commercially Cultivated Wheats of West Pakistan with Special Reference to a Semi-Dwarf Modern Wheat Variety, Mexi-Pak

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(Received June 30, 1970)

Summary

Six Pakistani wheat varieties grown in glass-house in separated pots were compared.

Mexi-Pak, a modern high yielding semi-dwarf variety with high response to fertilization, was high in specific leaf wight (leaf dry weight : leaf area) and in leaf areal nitrogen content as compared with other varieties. The specific leaf weight and leaf areal nitrogen content tended to be positively correlated with estimated net assimilation rate.

Mexi-Pak exhibited high dry-weight ratios of leaf to stem and leaf to root. Nevertheless, because of its high specific leaf weight, the leaf area ratio (leaf area: total plant dry-weight) was lower in Mexi-Pak as compared with other varieties. The leaf area ratio tended to be positively correlated with estimated relative growth rate.

Mexi-Pak, with a lower seed weight, a lower relative growth rate and a lower leaf area ratio, showed a lower plant dry weight and a lower leaf area at least when compared with the remaining varieties at the same number of days after planting grown in separated pots without any competition between single plants.

Differences in leaf photosynthetic rate per unit leaf area and transpiration rate of single attached leaves were observed among six commercially cultivated wheat varieties of West Pakistan by Khan and Tsunoda (1) and it was pointed out that Mexi-Pak, a modern semi-dwarf variety that yields high under heavy fertilized and properly irrigated conditions showed a higher photosynthetic rate on a leaf area basis than other old Pakistani varieties. In order to reveal a more complete picture of the differences in the growth especially for whole plants, the same six commercially cultivated varieties were compared during the year 1968–1969 using the growth analysis technique.

The essence of this method is the determination of the increase in dry matter, referred to a suitable basis of photosynthetically active tissue, e.g., leaf area or

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amount of leaf protein (2). Variations in dry matter accumulation by different varieties or species may be related to factors such as leaf area, net assimilation rate, leaf area ratio, relative growth rate, etc. This study was conducted to evaluate the relationships of these factors among cultivated varieties of West Pakistan.

In a previous investigation undertaken by Khan and Tsunoda (3) among cultivated wheat species and their wild relatives with special reference to the dry matter distribution among different plant organs and to leaf area expansion, the variations among strains in the relative leaf area development to the total plant weight, leaf weight and root weight and their relationships were briefly discussed.

A similar investigation was undertaken by Kranz (4). In his case the plants were cultivated and observed under field conditions with special reference to the relationship between the growth and the chlorophyll content of the plants. In the present and the previous investigations of the present authors, the plants were grown in pots in order to recover all the roots of the plants. Variations among strains in relative growth rate, net assimilation rate, relative leaf area development to the total plant weight, leaf dry weight to stem dry weight and root dry weight ratios will be discussed in this mansucript as key characters which may have a bearing on the growth pattern and the adaptibility to environmental factors.

Materials and Methods

The seeds of six commercially cultivated wheat varieties of West Pakistan listed in Table 1 and shown in Fig. 1 were grown in petri-dishes in an incubator at about 20–25°C and after germination they were planted in plastic pots (9 cm diameter by 20 cm height) containing river silt in the glass-house on December, 1st 1968. Two kernals were planted in each pot, one plant was left after thinning. Eighteen pots of each variety were raised. Pots were separated from each other

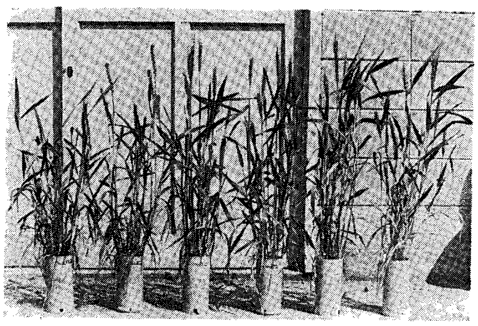

FIG. 1. Appearance of full grown specimens of the six commercially cultivated wheats of West Pakistan, used in the experiment. The plants shown here have been cultured in glass-house. The varieties are from left: Mexi-Pak, C 271, C 273, C 518, C 591 and C 228.

TABLE 1. *Characteristics of the Materials.*

S. No	Varieties	Year of approval	Parentage	General Characters
1.	C 228	1941	Hard Feder-ation ×9D	Plants tall, weak stemmed, ears bearded rather lax and smooth, grain amber and of good quality. Susceptible to three rusts. It was recommended for late sowings.
2.	C 271	1957	C230 ×IP 165	Plants tall somewhat stiff stemmed. Ears beardless, mid lax, glumes pubescent, grains amber and bold. Resistant to stripe rust but highly susceptible to leaf and stem rusts. It was recommended for rich soils.
3.	C 273	1957	C209×C591	Plants tall, ears bearded, mid dense, glumes white; grains amber and of good quality. Susceptible to three rusts. It was recommended for irrigated lands.
4.	C 518	1933	Type 9×8A	Ears bearded, densely fitted. Awns greyish black. Susceptible to three rusts. Stem better than C591. It was recommended for rich soils.
5.	C 591	1934	Type 9×8B	Plants tall, bearded, susceptible to three rusts, grains amber and attractive. It was recommended for irrigated lands.
6.	Mexi-Pak	1966	Penjamo× Gabo	Plants semi-dwarf, stiff stemmed and high tillering wheat variety. Ears bearded with higher number of florets. Grains amber and of medium quality. Resistant to stem and stripe rust but moderately susceptible to leaf rust.

and randomized at planting and repositioned randomly at various times during the course of the experiment. The plants were irrigated daily and when necessary large plants were given water twice a day. Nutrition (Ammonium sulphate 47 g, Sodium phosphate dibasic 25 g, and Potassium chloride 12 g) in

TABLE 2. *Dry Weights of Different Plant Organs and*

Varieties	Seed dry weight (mg)	January 10, 1969						
		Leaf area (cm^2)	Dry Weights (g)					Leaf Area (cm^2)
			Leaf	Stem	Root	Total		
1. C 228	47	28	0.08	0.05	0.07	0.21		127
2. C 271	54	27	0.08	0.06	0.07	0.21		158
3. C 273	48	38	0.11	0.07	0.05	0.23		149
4. C 518	45	36	0.10	0.07	0.09	0.26		165
5. C 591	46	33	0.08	0.05	0.08	0.21		134
6. Mexi-Pak	36	28	0.08	0.07	0.08	0.23		121

one litre of water was applied at the rate of 10 ml per pot before sowing and afterwards at 10–15 day intervals.

A random sample of 5 plants of each variety was taken starting 10th January, 1969 and finishing 10th March, 1969. The interval between sampling was 29–30 days. In all, three samplings were taken and the remaining 3 pots were used for photosynthetic, transpiration studies, etc. At the time of each sampling plant was washed with water, draining the whole soil gradually to recover all the roots of the plant from the pots.

The methods of determining and calculating the leaf area, relative growth rate, net assimilation rate, drying of the different plant organs, nitrogen analysis, etc. were the same as described in the previous paper (3).

Experimental Results and Discussion

Total Plant Dry Weight, Leaf Area Ratio, Relative Growth Rate, and Their Interrelationships.

The dry weights of different plant organs and leaf areas at various stages of growth development are presented in Table 2. The variation in the plant dry weight at a certain stage (number of days after planting) can be analyzed in terms of the initial seed weight and the relative growth rate (5).

As shown in Table 2, small differences were observed in the initial seed weight of the materials under investigation. The seed weight was the lowest in the Mexi-Pak variety as compared with the old varieties of West Pakistan.

The relative growth rate, which affects the plant dry weight, tended to be positively correlated with the leaf area ratio (leaf area : plant dry weight) as shown in Fig. 2. Positive correlation between these characters have been reported earlier in the cases of many other comparisons among and within species (3, 6, and 7). Further the leaf area ratio was negatively correlated with a net assimilation rate (Fig. 3). It is worthy to mention that the non-signfiicant results achieved in this experiment are due to the limited number of varieties involved,

Leaf Areas at Various Stages of Growth (per plant).

February 9, 1969				March 10, 1969				
Dry Weights (g)				Leaf Area (cm^2)	Dry Weights (g)			
Leaf	Stem	Root	Total		Leaf	Stem	Root	Total
0.48	0.35	0.35	1.18	406	2.06	2.30	0.85	5.21
0.57	0.45	0.36	1.38	484	2.21	2.52	0.91	5.64
0.56	0.39	0.39	1.34	553	2.69	2.72	1.24	6.65
0.59	0.38	0.41	1.38	642	2.97	2.82	1.43	7.22
0.50	0.33	0.34	1.17	524	2.54	2.12	1.00	5.66
0.50	0.33	0.31	1.14	450	2.53	2.21	0.76	5.50

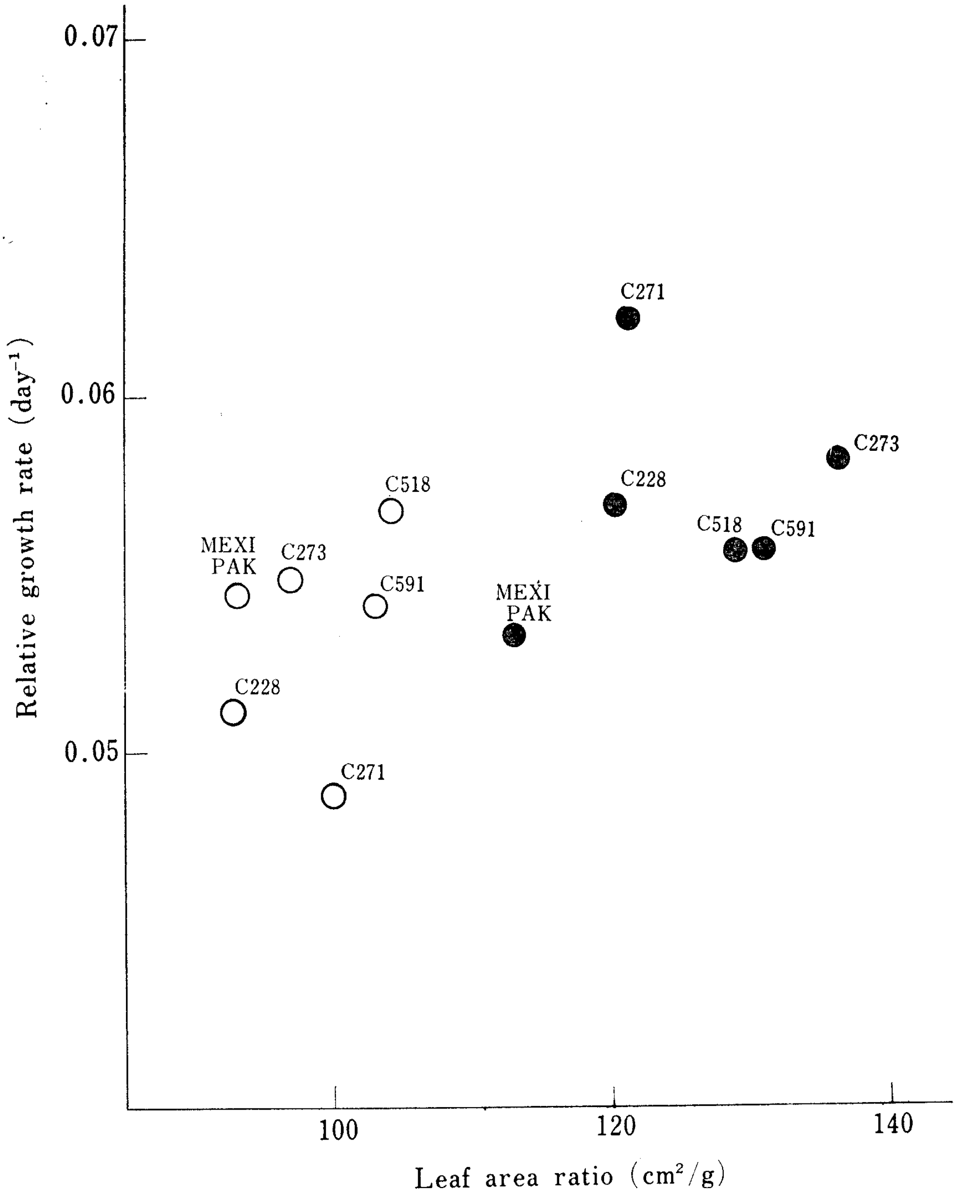

FIG. 2. Relationship between leaf area ratio and relative growth rate.
• January, 10~February, 9 r=+0.148
○ February, 9~March, 10 r=+0.248
Data in bulk r=+0.584*
* Significant at 5% level.

i.e., only six in these comparisons. Further, a negative correlation is found between leaf area ratio and total plant dry weight (Fig. 4). The modern high yielding variety, Mexi-Pak, tended to show a lower leaf area ratio and a lower relative growth rate associated with a lower plant dry weight, at least when compared with the other old varieties of West Pakistan at the same number of days after planting (Figs. 2 and 4). The observed differences in this ratio i.e., leaf area ratio is

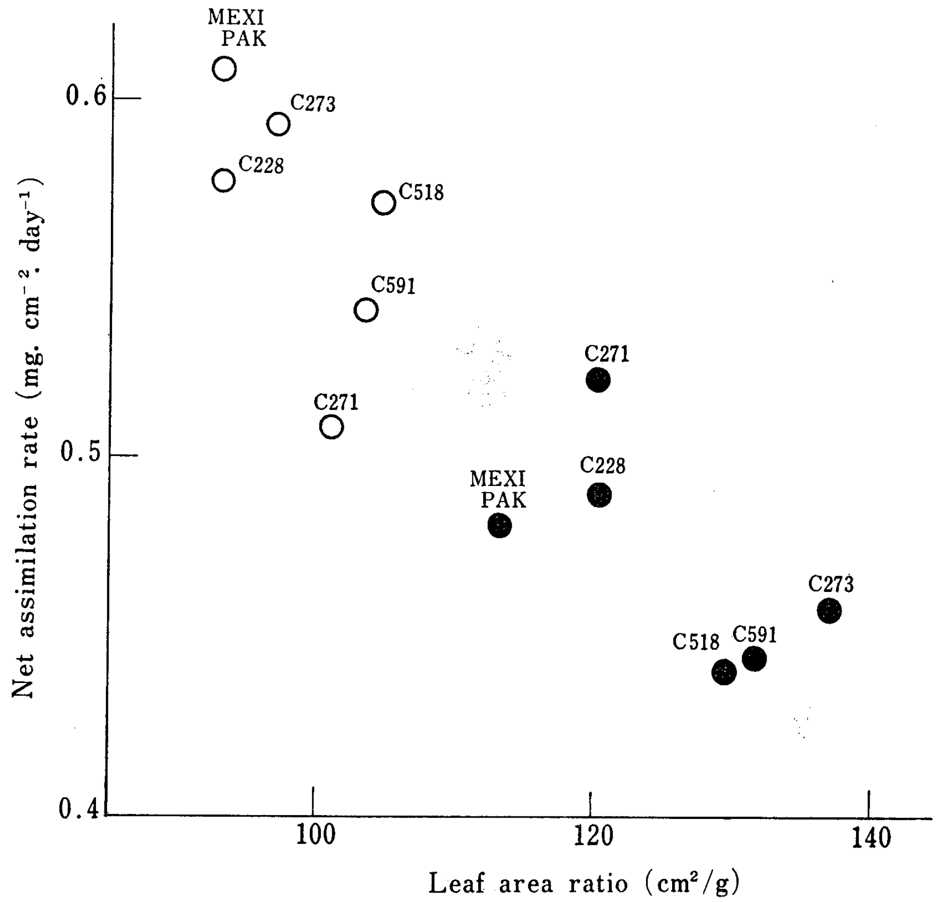

FIG. 3. Relationship between leaf area ratio and net assimilation rate
• January, 10~February, 9 $r=-0.644$
○ February, 9~March, 10 $r=-0.578$
Data in bulk $r=-0.887$**
** Significant at 1% level.

supposed to be a causal factor which affects the differences in the relative growth rate.

Varietal Variation in Total Leaf Area per Plant.

The results presented in Fig. 5 regarding the variation in the total leaf area per plant indicated that Mexi-Pak and C228 tended to develop lower leaf areas as compared with the other old varieties. As reported earlier in the previous paper (1) the Mexi-Pak variety is adapted to heavy manuring. Tsunoda (7) reported while discussing his results with rice, soybean and sweet potato that those varieties adapted to light manuring tended to have a larger leaf area per plant than those adapted to heavy manuring. He further narrated that varieties having a high ability of leaf expansion can not necessarily yield high under heavy manuring

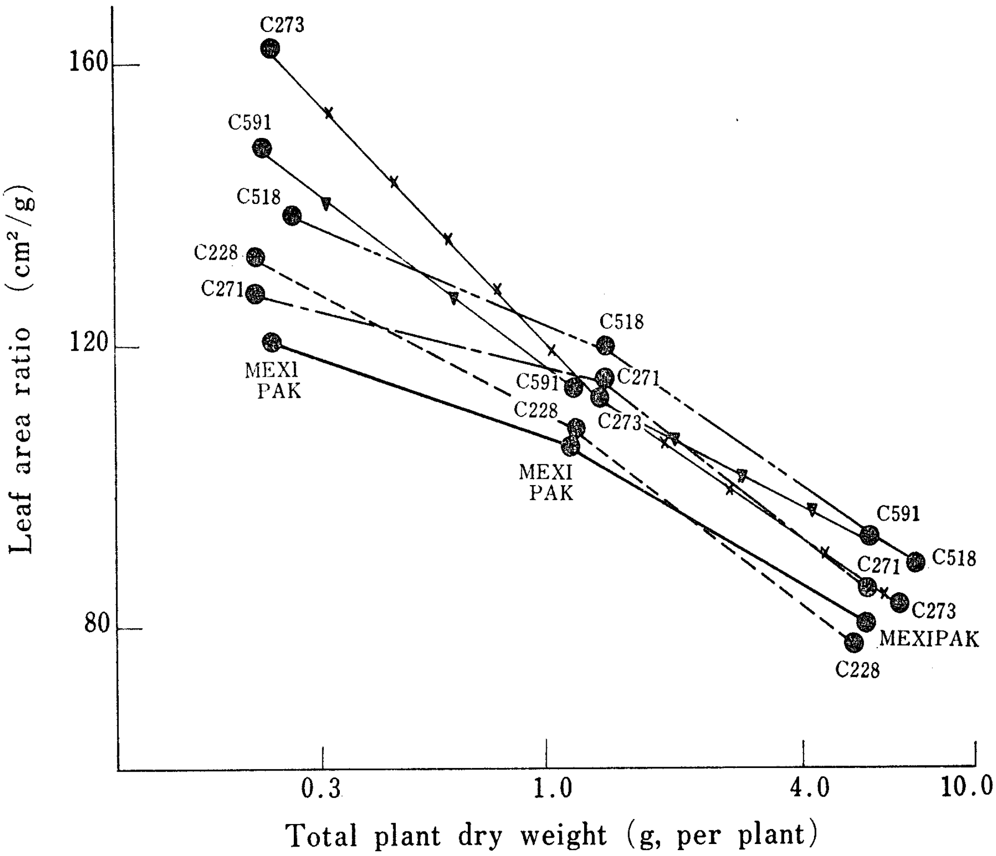

FIG. 4. Relationship between total plant weight and leaf area ratio

conditions because under such conditions the increase in leaf area does not necessarily result in an increase in the total dry matter production.

Varietal Variations in Leaf Area Development Relative to Root Dry Weight.

Variations in leaf area and root dry weight are presented in Fig. 5. Among all the varieties observed, when compared on the same level of root dry weight, it is seen that the Mexi-Pak variety showed the highest ratio of leaf area to root dry weight, whereas it is the lowest in varieties C273 and C518, respectively.

The relative development of the leaf area to the root dry weight may have a bearing on the balance of photosynthesis and nutrient absorption as well as on the balance of transpiration and water absorption under different levels of temperature, nutrient and moisture supply. The low leaf area to root dry weight ratio of the old commercial varieties may be the result of adaptation to light manuring and other hard environmental conditions of the winter growing season, plus the restricted moisture supply of the land where these plants were grown.

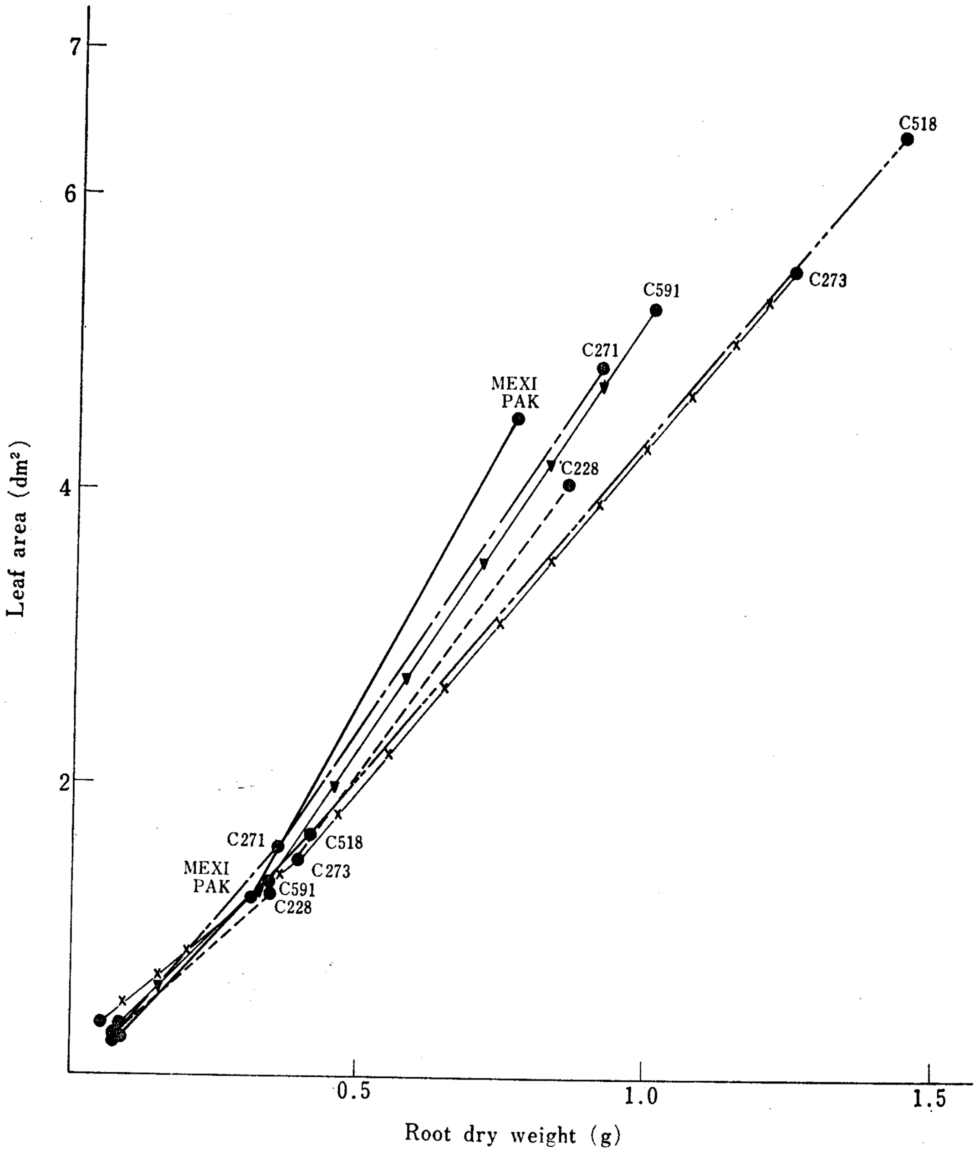

FIG. 5. Relationship between root dry weight and leaf area.

Ratios of Leaf Area to Leaf Dry Weight and Leaf Dry Weight to Stem Dry Weight and to Root Dry Weight.

The leaf area ratio discussed in the previous section can be analyzed in terms of the two components; the leaf area to leaf dry weight ratio and leaf dry weight to stem dry weight and to root dry weight ratios. Fig. 6 represents the relationship between leaf area and leaf dry weight and Fig. 7 the relationship between leaf dry weight and both stem and root dry weight.

It is quite clear from Fig. 6 that the leaf area to leaf dry weight ratio is lower in the Mexi-Pak variety than in the old commercial varieties of West Pakistan. The

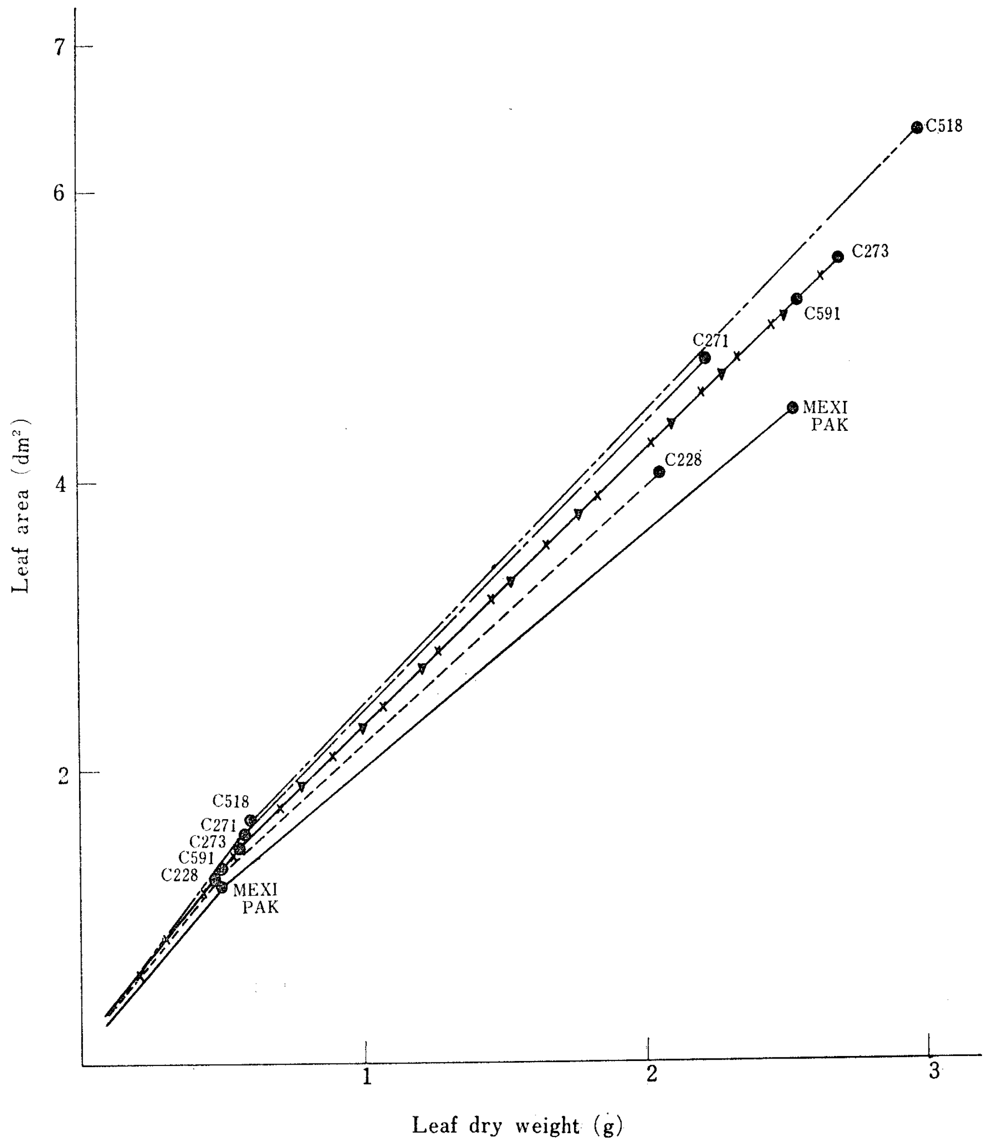

FIG. 6. Relationship between leaf dry weight and leaf area

Mexi-Pak variety has small, thick leaves and also has the highest specific leaf weight (leaf dry weight to leaf area ratio). Fig. 7 respresents the relationship of leaf dry weight to both stem dry weight and root dry weight. Here the Mexi-Pak variety showed the highest ratio for this character as compared with the others. This ratio can further be analyzed in terms of two components; the leaf dry weight to stem dry weight ratio and leaf dry weight to root dry weight ratio.

The data presented in Fig. 8 indicating the relationship between leaf dry weight and stem dry weight made it clear that the Mexi-Pak and C591 showed the highest ratio of leaf dry weight to stem dry weight as compared with the other

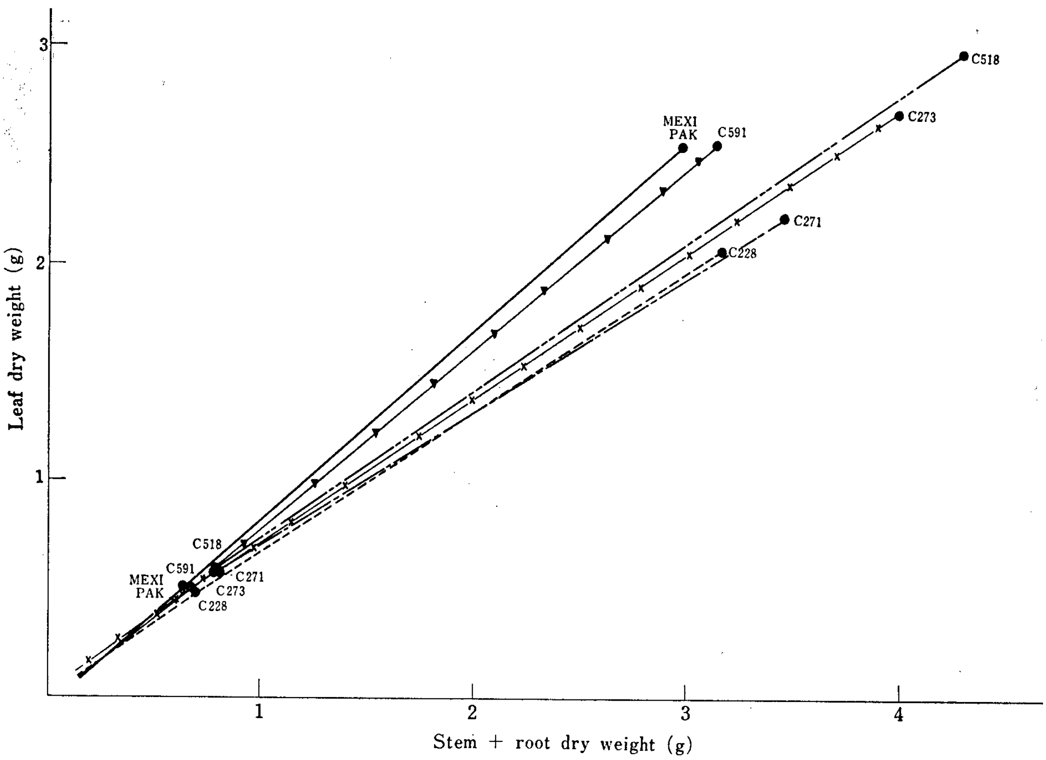

FIG. 7. Relationship between leaf dry weight and stem+root dry weights

varieties. In case of Mexi-Pak, the short stature seems to have a bearing for its low leaf-to-stem ratio.

The relationship between leaf dry weight and root dry weight is shown in Fig. 9 and revealed that the Mexi-Pak variety showed the highest leaf dry weight to root dry weight ratio among the materials under investgation.

Net Assimilation Rate, Specific Leaf Weight and Leaf Areal Nitrogen Content and Their Interrelationships.

The specific leaf weight on dry weight basis i.e., the reciprocal of the leaf area to leaf dry weight tended to be positively correlated with the estimated net assimilation rate as shown in Fig. 10. Further as presented in Fig. 11, the leaf areal nitrogen content also tended to be positively correlated with the net assimilation rate. These correlations were non-significant due to limited number of varieties involved in this experiment. Besides, the specific leaf weight and leaf areal nitrogen content tended to be positively correlated (Fig. 12).

These results coincide with those of the previous paper (1) where the photosynthetic activity of the single attached leaves was observed using a gas analyzer in relation to their leaf area, dry weight and nitrogen content. Similar results

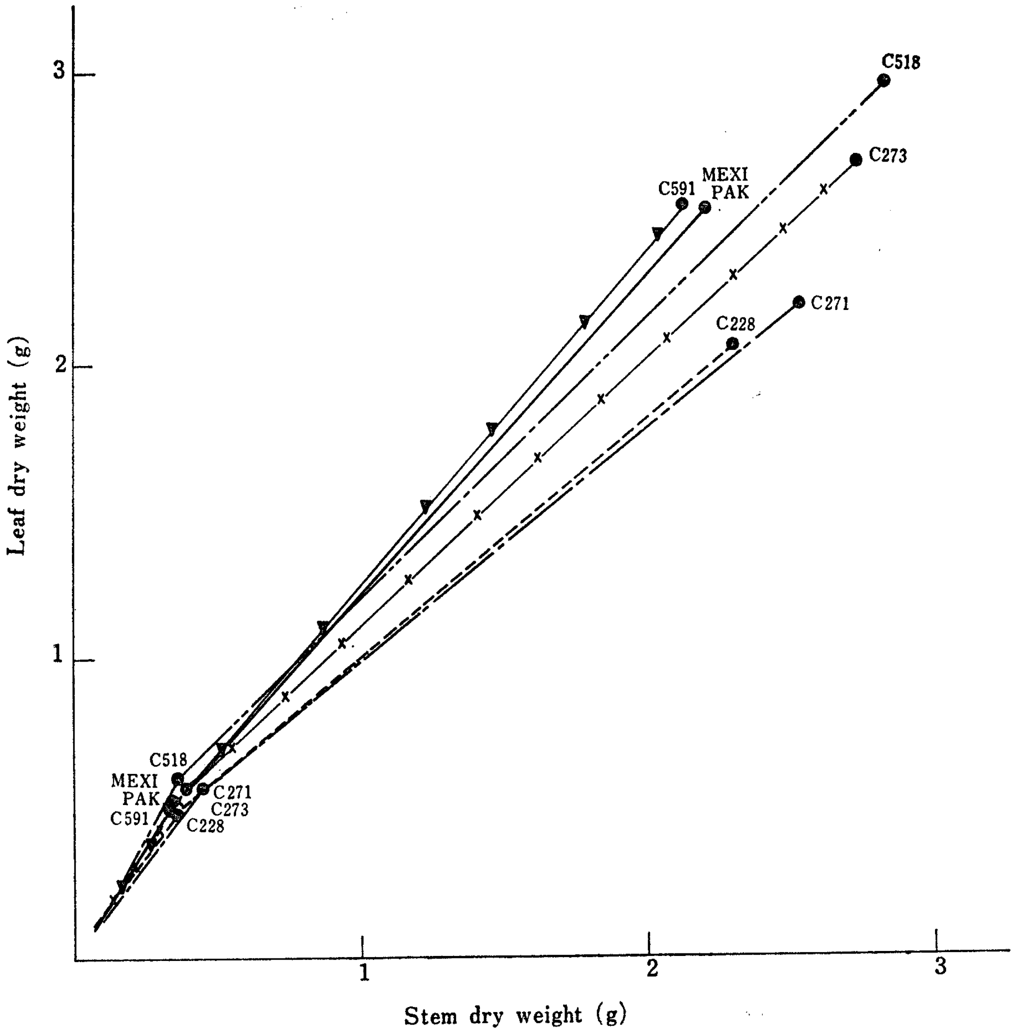

FIG. 8. Relationship between leaf dry weight and stem dry weight

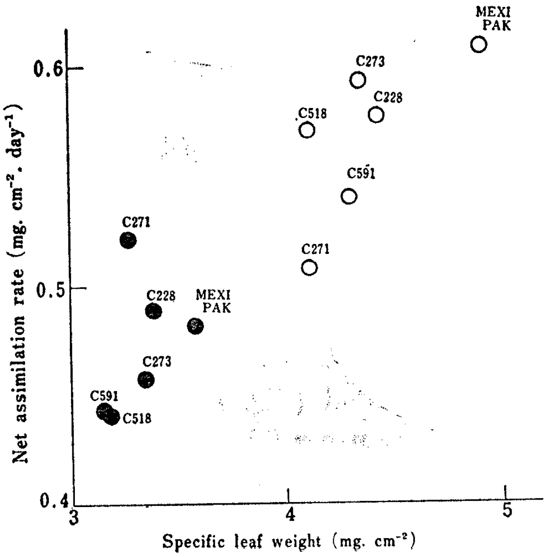

FIG. 10. Relationship between specific leaf weight and net assimilation rate

- • January, 10～February, 9 r=+0.428
- o February, 9～March, 10 r=+0.709
- Data in bulk r=+0.896**

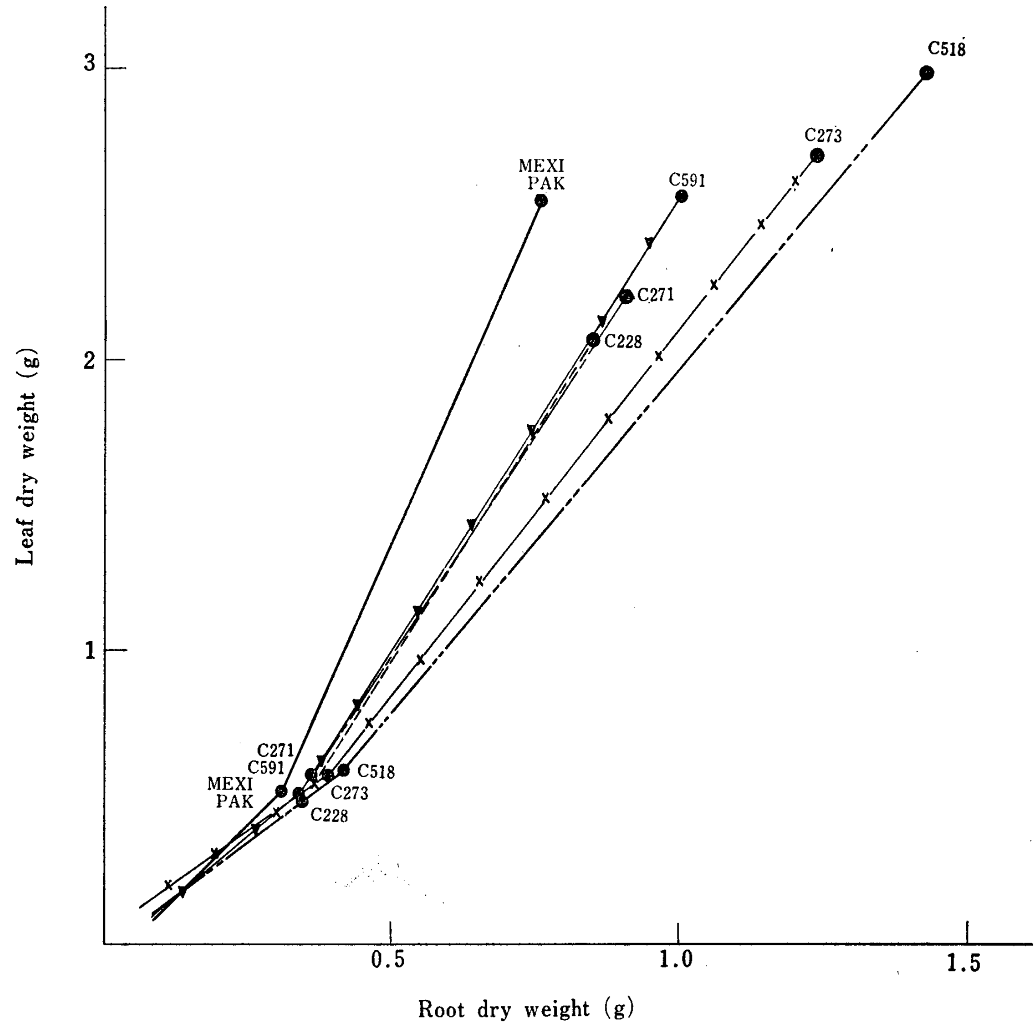

FIG. 9. Relationship between leaf dry weight and root dry weight

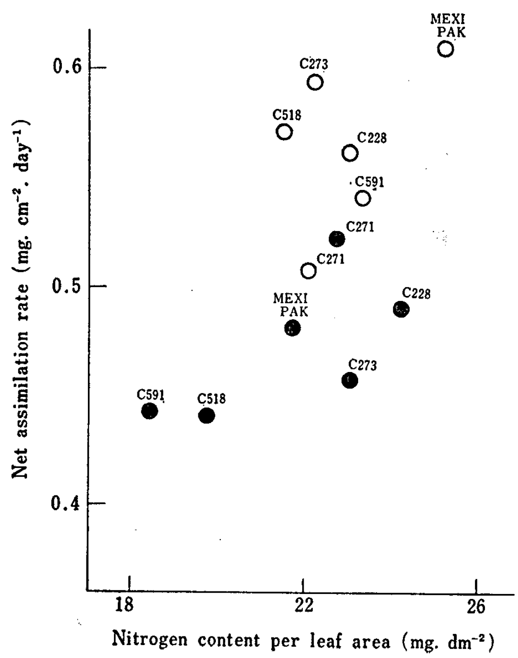

FIG. 11. Relationship between leaf areal nitrogen content and net assimilation rate

- • January, 10~February, 9 r=+0.679
- o February, 9~March, 10 r=+0.469
- Data in bulk r=+0.585*

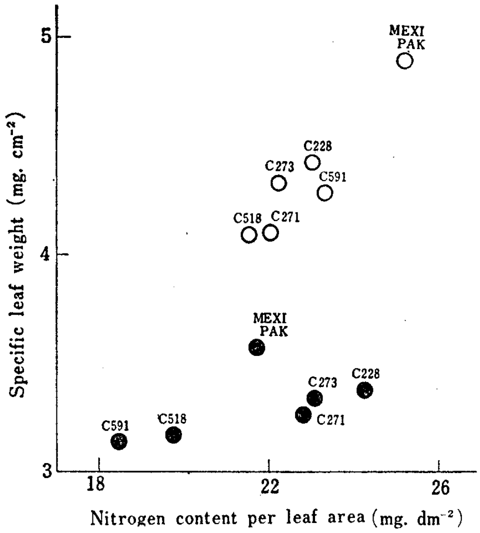

FIG. 12. Relationship between leaf areal nitrogen content and specific leaf weight
• January, 10~February, 9 r=+0.577
○ February, 9~March, 10 r=+0.942**

were also achieved in another growth analysis study with cultivated wheat species and their wild relatives which has already been reported elsewhere by Khan and Tsunoda (3).

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